

METHODS OF ENUMERATING HARBOR SEALS AT GLACIAL ICE HAULOUTS

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Significant numbers of harbor seals haul out on floating ice from tidewater glaciers in Prince William Sound (PWS), the northeastern Gulf of Alaska, and Southeast Alaska. Accurate counts of the number of seals at glacial haulouts are important to the National Marine Fisheries Service (NMFS) for their statewide abundance estimates, and to the Alaska Department of Fish and Game (ADF&G) as glacial haulouts may be included in population trend survey routes in the future. For example, glacial sites have the largest concentrations of harbor seals in PWS with seven glacial sites accounting for over half the total count (Table 1). The largest concentration of seals in PWS is found between the partially submerged moraine shoal and the face of Columbia Glacier. This site accounts for 25-40% of the count from ice sites and 15-20% of the total count for land and ice sites. Little is known about behavior of harbor seals at glacial sites.

Estimating population abundance at glacial haulouts has been problematic due to the large number of seals dispersed over a large area with a relatively uniform substrate. Smaller numbers of seals on terrestrial haulouts have been successfully estimated by direct counting or photographing sites using a 35 mm camera from a small aircraft (Frost *et al.* 1999, Small *et al.* 2001). This technique, however, does not work well when much larger numbers of seals are spread out over a larger area. As all seals on terrestrial sites can usually be included in one to 15 photographs, the larger glacial haulouts (e.g., Icy Bay in the northeastern Gulf of Alaska, Columbia Glacier in PWS) may require >100 photographs for complete coverage. For example in 1993, the largest concentration of harbor seals in Columbia Bay was scattered in 7 km of floating ice between a submerged shoal, that was the terminal moraine in 1978, and the face of the receding glacier (Burns 1994). The most difficult problem at glacial sites is accurately determining which seals remain to be photographed after censusing has begun, and then in assessing the amount of overlap between the large number of photographs. The most time-consuming, and perhaps, costly aspect of this work is mosaicing and counting photographs.

Pilot study of Prince William Sound, Fall 1999

From August 9 - 10, 1999, we conducted a pilot study focusing on the glacial haulout sites in PWS to assess the performance of a large format camera system with a GPS-link. Aerial photos ($n = 415$) were taken of 4 glacial sites (Meares Glacier/Unakwik Inlet, Harvard Glacier/College Fjord, Chenega Glacier/Icy Bay, and Columbia Glacier/Columbia Bay) using a large-format Zeiss RMKA camera mounted vertically in a Beaver aircraft. The program PHOTOMAN (developed by Rob Delong at the ADF&G) was used to link the camera to a GPS unit to control overlap between photos and transects for efficient coverage of sites, and to map photos for the final mosaic. No seals were present at the Yale Glacier (College Fjord) and only 1-2 seals were present at the Roaring (Harriman

Table 1. Proportion of counts of harbor seals at land-based versus glacial ice haulouts in Prince William Sound, Alaska. The seven ice sites include Icy Bay, Port Nellie Juan, Harriman Fjord, College Fjord, Unakwik Inlet, Columbia Bay Outside (seaward of submerged moraine shoal) and Columbia Bay Inside (between the moraine shoal and glacier face).

Area	1991	1992	1993	1998
North/West land sites ($n = 20$)	654 ^t	512 ^t	551 ^t	563 ^b
Eastern/Central land sites ($n = 25$)	920*	769*	774*	830*
Total land sites	1574	1281	1325	1393
North/West ice sites ($n = 7$)	968 ^a	1679 ^t	1555 ^t	1819 ^b
<i>Proportion of total count at ice sites</i>	<i>38%</i>	<i>57%</i>	<i>54%</i>	<i>56%</i>

* Data from Frost *et al.* 1999 (unadjusted counts)

^t Data from Burns 1994, sum of mean of four highest counts per site

^a Count does not include floating ice between the submerged moraine shoal and Columbia Glacier (Columbia Bay Inside)

^b Data from Burns 1998, calculated sum of mean four highest counts per site

Fjord) and Tiger (Icy Bay) Glaciers. No seals were present in Port Nellie Juan. Seals were very difficult to spot from the air at the Columbia Glacier due to dirty ice and the immense size of this site. However, nearly the entire area of floating ice between the submerged moraine and the glacier face was photographed on each day using complete successive transects with 50% overlap between successive photos and transects.

A total of 415 photos were obtained: 383 (90%) of Columbia Glacier and 32 of other sites. Surveys were flown at 800 ft.; few seals (<25) were flushed in the water at this altitude. Whereas the GPS-link and software worked well and met needs for control of coverage and mapping of photos, (1) seal images were small (0.5 to 1.0 mm in length) and nearly impossible to distinguish in areas of dirty ice; and (2) the large number of photos required for large sites made complete counts of photographs impractical, even when using large-format photography with a large swath width (e.g., resulting photographs covered approximately 1500 ft. or 457 m, per side).

Future options

Digital photography

A stronger lens on a large format camera will be needed to produce a smaller footprint and increased size of seal images in photographs. A large or medium format digital still camera or digital video camera may be particularly useful because digital images will greatly improve time-efficiency of mosaicing and counting photographs, and eliminate the need for high-resolution scanning of negatives. With smaller footprints, however, the use of strip transects rather than complete coverage will be necessary at large glacial sites. Even with a large footprint (strip width of nearly 500 m), >150 photographs were required for complete coverage of the Columbia Glacier site.

Thermal imaging

The use of large format or video photography may not be sufficient in areas of dirty ice (e.g., the Columbia Glacier), where thermal imaging may be the best option. Multispectral images could

provide both visual and thermal images for increased accuracy and comparison of the two image types. Two options for thermal imaging include (1) the use of FLIR (Forward Looking Infra-Red) and (2) contracting experts owning thermal scanners. We have examined FLIR videotape images of northern fur seals at the Pribilof Islands collected by Dave Cormany of the NMFS with cooperation from the Alaska State Troopers. This analog camera recorded in black-hot or white-hot, and color regular mode. GPS position, altitude and direction were continuously recorded on the tape. Individual fur seals and pups were distinguishable at an altitude of 1000 ft. It was also possible to identify birds on cliffs, such as cormorants, from an altitude of 500 ft. Image resolution, thermal imaging and continuous geo-referencing of images makes this system quite appropriate for harbor seal studies at glacial sites. Problems associated with FLIR, such as the need for a constant look angle and straight line to avoid complications with overlap and mosaicing, would need to be addressed. It may be possible to work with state troopers to test this system in PWS. Digital FLIR cameras may also now be available.

Contractors with thermal sensors and multispectral scanners are available to assist with harbor seal studies. For example, Scott Allen of BlueLink Geographic in Canada, owns a thermal sensor and has expertise in sensor operation and manipulation of resulting images. This system is not forward looking and has a thermal temperature resolution of approximately 0.5 degrees Celsius. Whereas the system is not usually used in wildlife studies, it has been quite easy to extract sheep and cows from the landscape on photographs taken when opportunistically flying over herds. The system has a pixel swath width of 590 per image. Flying at 5000 ft., the resulting resolution would be 0.90 m resulting in a swath width of 537 m. Data can be acquired from flight speeds of 140 to 180 kts though checking for smearing of individual animals at high speeds would be required. Testing would be required to determine the largest swath width with sufficient resolution for the specific application. Thermal images may allow larger footprints (smaller seal image size) than visual images to distinguish seals. Images are recorded directly onto a hard drive. The resulting images are fully GIS compatible and images are mosaiced automatically; the final mosaic is provided to the client. Costs are based on a per day rate for equipment, personnel and processing. A basic estimate for the PWS survey was approximately \$25,000 for five days of surveys and image processing. Other contractors are available, including AeroMap who submitted a proposal for this work.

Image mosaicing and counting

Working with digital images, from either a digital camera or scanned negatives, and imaging software would greatly reduce time and labor in mosaicing and counting photos back in the office. While the software program ERDAS Imagine allows automatic mosaicing of geo-referenced photographs and annotation layers to assist in counting of photographs, the software is quite expensive. We recommend the use of Photoshop to manually mosaic images and ArcView to assist in counting of photographs through annotation layers laid over mosaiced images. Annotation layers allow transparent "layers" to be laid down over images and researchers can use a mouse to mark each animal on the screen. After the count is complete the software tallies up the marks on the layer. Different layers can then be laid down and different marker symbols used to complete replicate counts and compare replicate counts to determine where discrepancies exist. Use of this technology should substantially increase time-efficiency and accuracy of counts. Working with multispectral images is also possible in ArcView. The NMFS took the lead on developing survey techniques in spring 2000 and continues to explore these and other options for surveying glacial sites. ADF&G will continue to work with the NMFS in developing survey techniques in the years 2000 - 2001.

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